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ABSTRACT

Two studies investigated whether young children acquiring verbs at an exceptional rate can use the syntactic structure of familiar and unfamiliar verbs to make conjectures about some aspect of the meanings of those verbs. The preferential looking paradigm (Golinkoff and Hirsh-Pasek, 1981) was used to set up a naturalistic pairing of scene and sentence for the children. Two different scenes were provided on two video screens. Both scenes involved the same physical action, for example "squatting." In one case, the action was presented in a causative manner; in the other, in a noncausative manner. While the videos were playing, the child heard either a transitive or a one-argument intransitive sentence. It was reasoned that if the transitive frame directed subjects' attention to the causative action, it could then be concluded that syntax functions to orient children to certain events in the world and not to others. Subjects in study 1 were 32 children between 27 and 30 months of age from English-speaking homes. Results suggested that children under the age of 2.5 years are able to make predictions about meaning with the use of syntactic information when actions are familiar and novel. Study 2, involving 32 children between 22 and 26 months of age, revealed that some children had begun to link some syntactic forms and semantic meanings. Results are discussed. (RH)

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FROM LINGUISTIC FORM TO MEANING:

EVIDENCE FOR SYNTACTIC BOOTSTRAPPING BY TWO-YEAR-OLDS

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From Linguistic Form to Meaning:

Evidence for Syntactic Bootstrapping by Two-year-olds

Why has so much attention been paid in recent years (and at this conference) to the acquisition of the verb lexicon? Why should we even _care_ about verb learning?

Well, the main reason is that the verb is one "cornerstone" (perhaps _the_ cornerstone) of the sentence. That is, the verb in effect _controls_ or determines the structure of the sentence (cf. Chafe, 1970). For example, if I want to talk about _throwing_, I must include some information about a thrower and a thrown [SLIDE]: that is, two NPs must appear in a sentence about throwing. If I want to talk about _dancing_, only one NP need appear: the dancer. [SLIDE] Finally, if I want to talk about _giving_, three thematic roles must be accounted for (the giver, the givee, and the given), [SLIDE] and so three NPs should appear in the sentence. These functions of the verb in constructing clause structure have been captured in various formal principles, such as the theta-citerion in Government-Binding theory, the Function-Argument Biuniqueness principle in Lexical Functional Grammar, and so on (Chomsky, 1981, Bresnan, 1982). In sum, we care about verbs because verbs and sentences seem to be mutually interdependent.

Our question about verbs is, how might children _learn_ them? One way they might do so is to observe the world, and match up

the action-in-the-world with the linguistic stimulus. This could also help in learning syntactic structures. The idea is that the scene in the world gets you the verb, and so a handle on what the structure of the sentence is. This view is part of the semantic bootstrapping procedure proposed by Bowerman (1974, 1983), Grimshaw (1981) and Pinker (1984), and convincing evidence has been accumulating to show that children do use such a procedure as they acquire language.

There may be another, supplementary, way to learn about verbs. This is to observe the sentence in which the verb is placed, and then make conjectures about some properties of the verb based on the structure of that sentence. This procedure of "syntactic bootstrapping" was proposed by Gleitman et al. (1987, see also Landau and Gleitman, 1985). Here, the sentence structure provides added information about the verb, just in case the visuo-spatial scene does not completely specify its meaning. The purpose of this paper is to present evidence for syntactic bootstrapping by children who are in the thick of verb learning; thus, we pick up the thread of evidence just where Lila left it off.

In our tests of the syntactic bootstrapping hypothesis, we are putting aside (for the moment) the question of how the child got to the point of being able to use syntactic forms to learn about meanings. We ask rather, to what extent does the syntax constrain the semantics of verbs in language learning? More specifically, we asked two questions: (1) Can young

children--that is, children who are in the thick of verb learning, acquiring verbs at an enormous rate--make conjectures about some aspects of the meanings of verbs, based on their syntactic structures, and (2) (most crucially) Can they do this for unfamiliar verbs as well as for familiar ones?

As some of you heard yesterday, the preferential looking paradigm developed by Kathy and Roberta (Golinkoff and Hirsh-Pasek, 1981) provides a means to detect the influence of purely linguistic stimuli on very young children's language comprehension. We employed this paradigm to set up a naturalistic pairing of scene and sentence for the children, while making no external demands on them, over and beyond mere looking.

Basically, we provided two different scenes on two video screens. Both involved the same physical action (for example, squatting). In one case, the action was presented in a causative manner--an agent (e.g., Big Bird) pushed a patient (e.g., Cookie Monster), into a squatting position (e.g., "Big Bird was squatting Cookie Monster"). In the other case, the presented action was noncausative--Cookie Monster and Big Bird were both squatting on their own (e.g., "Cookie Monster and Big Bird were squatting"). While these two videos were playing, the child heard one of two different linguistic stimuli. One was in the form of a transitive sentence (4)(novel sentence)

(4) Big Bird is squatting Cookie Monster [SLIDE]

The other was in the form of a one-argument intransitive (5/)

(5) Big Bird and Cookie Monster are squatting

sentence.

Our question concerned the relation between what was seen and what was heard. Did the particular linguistic input (that is, the syntactic frame: transitive versus intransitive) systematically direct the children's attention to a specific action? In particular, did the transitive frame direct their attention to the causative action? If so, this suggests that for these children, syntax does indeed orient them towards certain events in the world over others. More specifically, it would suggest that the children understand that the transitive frame (at least for motion verbs) implicates a causative interpretation for the verb in that frame.

METHOD--EXPERIMENT 1

Subjects

The subjects were 32 children, half males and half females, from the suburbs of Philadelphia, PA. They ranged in age from 27 to 30 months, with a mean age of 28.9 months. Their mean productive vocabulary was 316 words (out of 354 on L. Rescorla's vocabulary checklist (19xx)), and 30 of them were regularly producing three-word or longer utterances, while two were still in the two-word stage. All of the children were being raised in English-speaking homes.

Procedure

The method that we used to assess language comprehension was developed by Golinkoff and Hirsh-Pasek (1981). The infant sits midway between two video displays while a speaker between them plays a linguistic stimulus. [SLIDE] The linguistic stimulus "matches" or is consistent with only one of the two displays. Thus, the infant participates in a preferential looking video paradigm where the dependent variable is the amount of visual fixation to the matching versus the nonmatching screen. An observer hidden behind the video displays records the direction and duration of the infant's visual fix; she is blind to the particular experimental condition. The mother is also blind to the experiment, as she wears a visor over her eyes while in the testing room.

Stimuli

The layout of the tapes is shown in Table 1 on your handout. The left and right columns indicate videos, while the center column indicates the audio. [SLIDE] After an introductory passage that familiarized the subjects with the situation and the characters, the test of form-meaning understanding began. In somewhat abbreviated form, the procedure was as follows: The left screen comes on with a causative scene of Big Bird squatting Cookie Monster; the accompanying audio is the verb in its progressive form "squatting!". This lasts for 6 seconds while the right screen is blank. Between trials, the infant's attention is drawn to a center light between the screens. Then, the right screen comes

on with a non-causative scene of Big Bird and Cookie Monster squatting side by side, again accompanied by the progressive verb "squatting!". Next, both screens come on simultaneously with the same audio: the verb "squat" in its progressive form. The infant then receives two test trials per verb where the linguistic sample matches only one of the screens: for the transitive audio condition, this would be "See Big Bird squatting Cookie Monster? Look at Big Bird squatting Cookie Monster!" Following this, the next actions and verb are presented, in the same pattern.

A total of four sets of actions and verbs were presented. Two of these were Known Verbs (turn, bend), and two were Unknown Verbs (squat, flex). The status of the verbs as Known versus Unknown was corroborated by each mother after the test, and, as you will see, is independently corroborated by the structure of the findings..

Design

Each subject saw all four actions and heard all four verbs. Half of the children heard each verb presented in the transitive audio (e.g., "Big Bird is squatting Cookie Monster"), and the other children heard each verb presented in the intransitive audio (e.g., "Big Bird and Cookie Monster are squatting"). The side of the matching screen was counterbalanced across verbs and across subjects. Finally, all of the data were recorded on an Apple IIe microcomputer in an

adjacent room.

RESULTS

Our major question concerns the Screen factor: did the children look longer at the screen which matched the sentence they heard? If so, we can conjecture that they understood the relevant correlations between form and meaning (transitive frame/causative meaning and intransitive frame/non-causative meaning). Understanding these correlations would then give them a basis for learning new verbs via syntactic bootstrapping.

The results for the visual fix variable are presented in Table 2. [SLIDE] Clearly, children of both sexes, presented with either audio, tend to prefer the matching screen. A four-way ANOVA comparing sex, audio, known versus unknown verb, and screen shows that this preference is significant [$F(1,28) = 9.71$, $p = .004$]. However, the children's preference for the matching screen seems greater when presented with the transitive audio than when presented with the intransitive audio, and the interaction of Audio and Screen shows a trend in this direction [$F(1,28) = 2.76$, $p = .10$]. No other interactions with the Screen factor reached significance.

As an additional control (to make sure these subjects didn't just prefer the causative pictures overall), we analyzed

the visual fixes for the silent pairs (1. 24 in Table 1). These are trials in which both scenes are presented simultaneously, paired with an uninformative audio, and thus we can see what they looked at when they were not being directed. The results are listed in Table 3 on your handout: Clearly, there was no preference for either screen without the directing audio. This substantiates the preference found for the causative scene when the transitive audio <u>was</u> given.

Given the marginal interaction of Screen and Audio, we decided to look at the effects of transitive and intransitive sentence frames separately. When given the transitive audio, the children quite strongly preferred to look at the causative screen [$F(1,14) = 13.56$, $p = .0027$], and there were no significant interactions with verb type or sex. When given the intransitive audio, though, there was no significant preference for either screen: they looked randomly back and forth [$F(1,14) = .91$, ns].

Thus, it appears that by 28 months of age, children of both sexes understand at least that motion verbs in transitive sentences represent or describe causative actions. Even more importantly, these children understand this for novel actions and unknown verbs; they have codified the correlation in terms of a particular sentence type and action type. Syntactic bootstrapping seems to be operating with the transitive frame and causative meaning, since the structure of the sentence constrains the interpretation of the verb which is contained in

it. The status of the intransitive frame, and its implication for semantic interpretation, is not as clear, and we will return to it in later discussion.

EXPERIMENT 2--YOUNGER KIDS

The results of Experiment 1 suggest that children under the age of two-and-one-half years are able to make predictions about meaning based on syntactic information. Not only can they use the syntax to discriminate uses of known verbs, but they can also use it to make conjectures about novel actions and novel verbs--such as squat and flex, which were novel for them. We ask now, what is the youngest age at which children can do this? We have some additional data which are relevant to this question.

We have also tested a younger group of subjects with these same videotapes. These subjects were again 32 in number, half males and half females. They ranged in age from 22 months to 26 months, with a mean age of 24.5 months. Their mean productive vocabulary was 231 words (according to maternal report), and 19 of them were regularily producing three-word utterances, while the other 13 were still in the two-word stage.

The stimulus videotapes, procedure, and experimental design were exactly the same as with the older group of

subjects. [Recall that we were looking to see if the children looked longer at the screen that matched the audio they heard; for example, if they looked longer at the screen depicting the causative action when given the transitive audio]. The results for this group, already split in known and unknown verbs, are presented in Table 4. [SLIDE] As in the previous Experiment, appropriate controls were provided by the silent pairs, to make sure that there was no undue preference for one screen over the other.

Looking at the Table, it appears that children of both sexes look longer at the matching screen only when given known verbs in the transitive audio. [CIRCLE ON SLIDE] Without going into all of the statistical ins and outs, there was one and only one significant effect: for the girls presented with the transitive audio, a significant effect of match over non-match was obtained for the known verbs [$t(7) = 3.12$, $p<.02$]. Every other effect of and interaction with Screen was random.

At the tender age of 24 months, then, there is some evidence that some children have begun to link some syntactic forms and semantic meanings. The understanding seems restricted, though, to the girls in the sample who heard transitive sentences containing known verbs. That is, the 24-month old girls can make the transitive frame-causative meaning correlation, but apparently only for the verbs (turn and bend) that they already know.

These results, while not overwhelming, suggest that the ability to link forms and meanings, and to use the theta-criterion, is beginning to kick in at this age. For these barely two-year-old girls, the syntactic structure does provide a way to discriminate the usage of known verbs. They are beginning to understand the semantic implications of syntactic organization, which is the basis for using syntactic bootstrapping to learn new verbs.

DISCUSSION

The results of these two experiments, taken together, provide a picture of the child's developing ability to link forms and meanings, and to use these links to make predictions about the meanings of new verbs. By the age of just two, girls understand the correlation between transitive sentences and causation well enough to be able to use the syntax to discriminate between causative and noncausative uses of known motion verbs. Children who are just four and one-half months older, both boys and girls, can go beyond this, using the syntax to predict the scenes appropriate for new verbs. That is, these children are enough in command of the theta criterion or function-argument biuniqueness principle that they can use it to make conjectures about new lexical items. We provide here, thus, evidence of the child's growing ability to use syntactic bootstrapping to learn the meanings of verbs.

While there was, for both age groups, an overall significant preference for the matching screen, supporting the influence of syntax on discriminating and predicting verb meaning, its magnitude was affected by two main factors: the familiarity of the verb and/or action, and the audio type. I now offer some thoughts on how these effects can be interpreted in the light of syntactic bootstrapping.

The effect of verb type comes up only in the 24-month-old group, in that these girls prefer the matching screen only when they are presented with known verbs and known actions. Why does this effect first show up only with the known verbs? To answer this, we need to review some assumptions about what the child brings to the syntactic bootstrapping procedure. One item of knowledge the child must have is that a certain syntactic frame correlates with, or implicates, a certain component of meaning. This correlation should be understood independently of the particular verb in the frame--that way, it can be used to deduce meanings for new verbs. Suppose, however, that the child has not yet formulated the correlation independently of the verb--as Lila pointed out, these mappings have to be learned. Suppose that the child is just noticing that turn in the transitive frame always involves a causative kind of turning, but has not yet generalized this to all transitive frames, and all causative actions. If this was the case, we would expect the results which were obtained: a strong effect of the syntactic frame in orienting the child to a particular event, for the known verbs, and random looking for

the unknown ones.

Now, as to the other, more pervasive effect on preference for the matching screen: the audio type. While most of the children in both age groups looked at the matching, causative scene when presented with the transitive audio, they showed no preference for either scene when presented with the intransitive audio. This result could suggest that these children have not yet made the form-meaning correlation that intransitive frames for motion verbs generally indicate noncausative meaning. As such, it would corroborate evidence from production data, such as Bowerman's (1974, 1983), that children at this age rarely overgeneralize in this direction. However, this may be a premature conclusion, given some comprehension findings gathered by myself, Lila, and Henry Gleitman (Naigles, Gleitman, and Gleitman, 1987)which suggested that children not too much older than our 28-month olds do seem to show the effect in the intransitive direction. We are currently running another condition with the present videotapes in which we are trying to replicate this finding.

It is important to realize, though, that even if this new manipulation with the intransitive audio does not yield the expected result, the results from the transitive audio still hold, and still provide solid evidence of the child's use of syntax in figuring out verb semantics.

Finally, I would like to give you a sense of some data

which I am now gathering as part of my own thesis work. These results may provide a still more compelling test of the syntactic bootstrapping hypothesis. In this study, I ask children to use the syntax to determine which of two completely novel actions a nonsense verb refers to. This attempts a fairly close simulation of the actual verb learning environment, in which, as Lila described, pure observation cannot always provide complete information about the particular meaning of the presented verb. The procedure again utilizes the Golinkoff and Hirsh-Pasek preferential looking paradigm.

Picture a scene, where Big Bird is forcing Cookie Monster into a position characteristic of several well-known stretching exercises. Simultaneously, Big Bird and Cookie Monster are each making arm circles. [SLIDE] Thus, there are two actions going on, simultaneously: a causative one, and a noncausative one. This scene is presented three times to the children: on the left screen, on the right screen, and then both screens on at once. With each presentation is paired the transitive audio: "Oh look! Big Bird is blicking Cookie Monster!" (This is the teaching phase, so to speak). Then, the two actions are split up: one screen shows <u>only</u> Big Bird making Cookie Monster go into the stretching position, while the other screen, displayed at the same time, shows <u>only</u> Big Bird and Cookie Monster making arm circles. The audio for this trial, which is the control, or silent pair, is "Oh, they're <u>different</u> now!" Then, the same two scenes come on two more times, with the test audio, "find blicking now." These trials test what, if

anything, the children have learned. After this, three more such novel action pairs and nonsense verbs are presented, in the same pattern.

The child's visual fix during these test trials is again the dependent variable--it shows whether she has used the syntactic frame of the introductory audio to select which of the actions the sentence--and the verb--is talking about. For the transitive audio used here as the example, the child should look longer at the causative scene during the test--the stretching scene. If she does, this would indicate that she has learned a brand new verb--and that this new verb is causative--by attention to the syntax of the sentence. If the intransitive audio "oh look, Big Bird and Cookie Monster are blicking!" was used, the child should look longer at the noncausative scene--the arm circles one, having learned a new, noncausative verb.

I have tested 10 children so far, between the ages of 23 and 27 months, mean age 25 months. Eight of the children watched the video paired with the transitive audio, and of these eight, seven looked longer at the matching, causative screen. Two children have watched the video paired with the intransitive audio, and both of them looked longer at the matching, noncausative scene. Thus, so far, the predictions of syntactic bootstrapping hold very strongly in the most dramatic test yet--9 matching children out of a possible ten! I caution you that these results are only preliminary; however, they are

certainly exciting, as they suggest that syntax is indeed used by very young children to pick out, nay, to learn aspects of new verbs, when observation of the visuo-spatial scene is clearly insufficient.

If these results continue to hold up, then they will provide stronger evidence that syntactic bootstrapping can be used in cases of total ambiguity, to learn about new verbs. The suggestion that children at 25 months of age can go from form to meaning even with completely novel verbs and actions may also require us to revamp our interpretation of the known-unknown verb distinction made earlier. In any case, it provides further incentive to look at even younger children, in order to establish just when this ability to use syntax to learn about semantics comes in.

In sum, all of these studies point towards the use of syntactic bootstrapping--deducing meaning from form--as one procedure for learning about verbs. Needless to say, it cannot be the only procedure for this purpose--something like semantic bootstrapping must also play a role. Still, perhaps we should revise something from our introduction to this paper. Remember, I said that one reason to care about verbs is that verbs tell us important things about sentence structures. It is apparent from these experiments, though, that this is a two-way street: sentence structures also tell us--and children--important things about verbs.

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Naigles, et. al.

TABLE 1: Layout of Videotape

Tape 1	Audio	Tape 2
20 BigBird is pushing Cookie Monster into a squatting position	See, squatting!	Black
22 Black	Look, squatting!	Big Bird and Cookie Monster are squatting side by side
24 BigBird is pushing Cookie Monster into a squatting position	See, squatting!	Big Bird and Cookie Monster are squatting side by side
26 BigBird is pushing Cookie Monster into a squatting position	Find Big Bird squatting Cookie Monster!	Big Bird and Cookie Monster are squatting side by side
28 BigBird is pushing Cookie Monster into a squatting position	Look at Big Bird squatting Cookie Monster!	Big Bird and Cookie Monster are squatting side by side

TABLE 2: Mean visual fixation time to matching screens, in seconds

Audio	Matching	Nonmatching	F
Transitive (n=16)	3.56	2.24	13.56*
Intransitive (n=16)	3.08	2.68	0.91
Total	3.32	2.46	9.71*

*p<.01

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Naigles, et. al.

TABLE 3: Mean visual fixation to causative and noncausative actions for the silent pair trials (1.24 in TABLE 1)

	Causative	Noncausative	
Visual fix (in seconds) n=32	2.92	2.885	t(31) = .297, ns

TABLE 4: Mean visual fixation time to matching screens, by verb type, for the 24-month-old group

Sex	Audio	Known Verbs		Unknown Verbs	
		Match	Nonmatch	Match	Nonmatch
Boys					
	Transitive	3.21	2.63	2.33	2.62
	Intransitive	2.76	2.58	2.27	2.11
Girls					
	Transitive	3.8	1.39*	1.94	2.64
	Intransitive	2.3	2.96	3.31	2.45

*Post-hoc t(7) = 3.12, p<.02